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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **An improved glow plug having a resistive surface film heater.**

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Description

The present invention relates to the field of electric heaters for the ignition of hydrocarbon fuels and in particular to glow plugs for assisting the start of Diesel type internal combustion engines.

Electrically energized glow plugs are currently used in compression ignited or Diesel type internal combustion engines to assist in the ignition of the air/fuel mixture during cold starts. In particular glow plugs are essential in northern states during the winter months when ambient temperatures fall below 10°C.

Currently, glow plug, such as that disclosed in US—A—4,281,451 and US—A—4,345,555 have a coil wire heater enclosed in a protective metal shield. The problem with such glow plugs is that they have a relatively low thermal response time, 15 to 30 seconds, and require relatively large currents, 15 to 25 A, to bring them up to the required operating temperature. The prior art also teaches replacing the coiled wire heating element with a spiral wound flat tape type heating element as disclosed in US—A—4,297,785. Alternatively US—A—4,357,526 and US—A—4,035,613 each describe a discrete printed circuit heating element embedded in a ceramic body. However, all of these glow plugs still exhibit the same slow thermal response and relatively high electrical power requirements.

In contrast to the glow plugs described above, GB—A—2,092,670 describes a glow plug having a layered platinum-rhodium alloy surface film heater element applied to the base of a closed end ceramic tube.

However, such a glow plug also suffers from the problems of slow thermal response and the need for high electrical power.

It is therefore an object of the present invention to provide a glow plug which is more efficient than those previously described, is of simple construction and which has improved electrical contacts.

According to the invention there is provided a glow plug comprising a hollow cylindrical metal shell, an axial terminal disposed concentrically in said shell and insulated therefrom, an electrically nonconductive cylindrical substrate having an internal portion retained within the shell by the axial terminal and an external portion axially extending from the shell, a resistive surface film heater element disposed along at least the external surface of the substrate, one end of said heater element in electrical contact with the shell and the other end of the heater element in electrical contact with the axial terminal characterised in that the cylindrical substrate further comprises a concentric bore passing through the whole length of the substrate, and said heating element extends around the end of the substrate's external portion and along the internal surface of axial bore.

One advantage of the present invention is that the cylindrical heating element forms a hot cul-de-sac region isolated from the cooling effects of impinging air/fuel mixture and enhances ignition.

Another advantage of the glow plug is that both connections between the heater element, the shell and the axial electrical terminal are made internal to the shell and not exposed to the high temperature and corrosive atmosphere of the engine. Still another advantage of the glow plug is that the heater element is located at the tip of the ceramic substrate minimizing the protrusion needed into the engine's ignition chamber reducing interference of the glow plug with the ignition chamber's air flow pattern. These and other advantages of the improved glow plug will become more apparent from a reading of the specification in conjunction with the drawings.

Brief Description of the Figures

FIGURE 1 is a cross section of the improved embodiment of the glow plug.

FIGURE 2 is an enlarged cross-section showing the details of the heater member.

FIGURE 3 is an enlarged cross-section of a second embodiment of the heater member.

FIGURE 4 is an enlarged cross-section of a third embodient of the heater member.

FIGURE 5 is a cross-section showing the glow plug mounted in the swirl chamber of a diesel type internal combustion engine.

Detailed Description of the Invention

A cross-sectional view of the glow plug is shown in FIGURE 1. The glow plug 10 comprises a cylindrical metal shell 12 having an internal bore 14. Formed at one end of the shell 12 is a contact seat 16 defining a heater aperture 18. Located in the internal bore 14 is a heater member 20 having a resistive surface film heater element 24 coated or disposed on at least one surface of a nonconductive substrate 22 adjacent to one end thereof as shall be described hereinafter. The nonconductive substrate 22 is preferably a high temperature ceramic, but may be quartz, a high temperature glass, or metal sleeve coated with an insulating material. The substrate has an internal bore 26, a base or internal portion 28 disposed in shell 12 and a smaller diameter external portion 30 protruding external to the shell 12 through the heater aperture 18. Heater aperture 18 has a diameter smaller than the diameter of internal portion 28 of the substrate 22 and larger than the diameter of external portion 30.

An axial electrical terminal 36 has a radial flange 38 and guide 40 formed at one end. The guide 40 is received into the internal bore 26 of substrate 22 with one face of the radial flange 38 abutting the internal end face 42 of the substrate 22 with a force sufficient to deform an electrically conductive gasket 32 interposed between a shoulder 34 of the substrate 22 and the shell contact seat 16. The conductive gasket 32 may be copper, gold or any other maleable metal or alloy.

A cylindrical insulator member 44, similar to the insulator commonly used in spark plugs, is inserted in bore 14 circumscribing axial electrical

terminal 36 and abutting the opposite face of radial flange 38. The end of the shell 12 is crimped over to form a peripheral lip 46. The insulator member 44, axial electrical terminal 36 and heater member 20 are then locked tightly inside of shell 12 by a hot press operation which heats, then cools and undercut groove 95 while a compressive force is applied between peripheral lip 46 and the opposing end 96 of an external hexagonal portion 50. The shell 12 further includes an externally threaded portion 48 for mounting the glow plug 10 in the engine. The external hexagonal portion 50 facilitates threading the glow plug into an appropriate threaded aperture of the enginee.

One advantage of the glow plug shown in FIGURE 1 is that the electrical connections between the surface film heater element 24, the shell 12, and the axial electrical terminal 36 are made internal to the shell 12 where they are protected from the high temperatures and corrosive atmosphere inside of the engine. This configuration eliminates the electrical terminal corrosion problems encountered with the prior designs.

The details of the heater member 20 are illustrated in FIGURE 2. Referring to FIGURE 2, the heater member 20, as previously described, has a generally cylindrical substrate 22 having an internal bore 26, an internal portion 28, a smaller diameter external portion 30, and a sloped shoulder 34 connecting the external surfaces of the internal portion 28 and external portion 30. The edges at end face 52 of the substrate 22 are ground to form radii blending the end face 52 with the contiguous internal surface of bore 26 with the external surface of the substrate or may be ground to form a full radius as shown. In a similar manner a ground radius 54 is formed at the base of the substrate blending the end face 42 with the internal surface of bore 26.

A highly conductive metal film 56 is circumferentially coated on the surface of shoulder 34 and a predetermined distance along the external surface of the external portion 30 of the substrate leaving a first uncoated portion 60 adjacent to end face 42 and a second uncoated portion 64 adjacent to end face 52. A similar highly conductive metal film 58, is coated on the internal surface of cylindrical substrate 22 and extends around radius 54 onto end face 42 as shown. The metal film on the end face 42 has a diameter smaller than the diameter of the internal portion 28 leaving an uncoated peripheral portion 62. The highly conductive metal films 56 and 58 may be transition metal films, gold films, alloys thereof or any other metal or metal alloy films.

A resistive metal surface film heater element 24, having a resistance greater than 0.2 ohms is deposited on the uncoated portion 64 of the substrate and on end face 52. Preferably the resistance of heater element 24 is between 0.4 and 0.6 ohms. Heater element 24 and the conductive metal films 56 and 58 overlap providing for electrical contact therebetween. Preferably the resistive metal of heater element 24 is of the platinum family consisting of platinum, rhodium, palladium, iridium and alloys thereof. Alloys having higher melting temperatures, such as alloys containing tungsten and at least one transition metal may be used to increase the operating temperature of the glow plug.

The primary advantage of the cylindrical configuration of the heater member is that the bore 26 form a high temperature cul-de-sac adjacent to its open end which is isolated from the cooling effects of the swirling air/fuel mixture in the engine's ignition chamber. The air/fuel mixture entering the high temperature cul-de-sac formed by bore 26 is more readily ignited than the air/fuel mixture impinging on the external surfaces of the heater member enhancing the ignition efficiency of the glow plug.

In the assembly of the glow plug one end of the heater element 24 is in electrical contact with the shell 12 through surface film 56 on shoulder 34 and electrically conductive gasket 32 while other end of heater element is in electrical contact with axial electrical terminal 36 through surface film 58 on the internal surface of bore 26 and radial flange 38 abutting the extension of surface film 58 onto the end face 42.

In an alternate embodiment of the heater member 20 shown in FIGURE 3, the bore 26 of the substrate 22 is tapered outwardly at end 52 to enhance the depth at which the heater element 24 may be coated into bore 26. This permits the heater element 24 to wrap around end face 52 and extend a short distance into bore 26 as shown. This further enhances the formation of the high temperature cul-de-sac as previously described.

In contrast to the arrangement shown on Figures 2 and 3 the heater element 24 may be coated on the internal surface of the ceramic substrate defined by bore 26 as shown on Figure 4. In this configuration the conductive metal film 56 extends along the external surface of the substrate adjacent to end face 52. The conductive metal film 58 extends along the internal surface of the substrate and onto end face 42 as in the prior embodiments. This configuration further enhances the high temperature cul-de-sac formed in the bore 26 of ceramic substrate adjacent to the external end face 52.

Because the heater element 24 is located adjacent to the tip of the glow plug, it is no longer required for the glow plug to protrude fully into the ignition chamber of the engine. Referring to FIGURE 5 there is illustrated a typical swirl chamber 68 of a diesel type engine having an aperture 70 communicating with the corresponding engine cylinder. As is known in the art, air is pumped in and out of the swirl chamber 68 with the reciprocation of the cylinder's piston as indicated by dashed double headed arrow 72. Fuel from a Fuel Injector 74 is injected into the swirl chamber where it is mixed with the swirling air to form a combustible air/fuel mixture. Because the heater element 24 of the improved glow plug 10 is formed at the tip of the substrate 22, only the tip of the glow plug need to protrude

into the swirl chamber 68 as shown. In this way the glow plug 10 produces minimal interference with the swirling air pattern inside of chamber 68. In fact, tests conducted to date indicate efficient ignition of the air fuel mixture can be obtained with the glow plug mounted in the glow plug well 76 with the tip disposed flush with the internal walls of the swirl chamber 68.

The advantages of the improved glow plug are as follows:

1. The low mass of the surface film heater element 24 permits the glow plug to reach an operational temperature above 800°C in less than 5 seconds.

2. The watt density of the surface film heater element 24 exceeds that of bulk material giving rise to current requirements averaging in the range from 3 to 7 A at operating temperatures.

3. The transition metal heater element 24 exhibits catalytic action enhancing the ignition of the air/fuel mixture at lower temperatures.

4. The internal surface of the heater member 20 adjacent to external end face 52 remains at the ignition temperature of the air/fuel mixture regardless of the cooling from fuel or air in the ignition chamber.

5. Because the heater element 24 is located at the tip of the glow plug, only the tip of the glow plug needs to protrude into the ignition chamber producing only minimum interference with the ignition chamber's fluid flow pattern.

6. The electrical contacts to the conductive surface films 56 and 58 are made within the shell 12 reducing their exposure to the higher engine temperatures reducing their oxidation and corrosion.

7. The components of the glow plug are applicable to standard spark plug manufacturing techniques and therefore are potentially less costly than glow plugs using spiral wound wire heaters.

Claims

1. A glow plug comprising a hollow cylindrical metal shell (12), an axial terminal (36) disposed concentrically in said shell (12) and insulated therefrom, an electrically nonconductive cylindrical substrate (22) having an internal portion (28) retained within the shell (12) by the axial terminal (36) and an external portion (30) axially extending from the shell (12), a resistive surface film heater element (24) disposed along at least the external surface of the substrate (22), one end of said heater element (24) in electrical contact with the shell (12) and the other end of the heater element (24) in electrical contact with the axial terminal (36) characterised in that the cylindrical substrate (22) further comprises a concentric bore (26) passing through the whole length of the substrate (22), and said heating element (24) extends around the end (52) of the substrate's external portion (30) and along the internal surface of axial bore (26).

2. A glow plug as claimed in Claim 1 wherein said heater element (24) has a resistance greater than 0.2 ohms.

3. A glow plug as claimed in Claim 1 wherein said heater element (24) is a metal film.

4. A glow plug as claimed in Claim 3 wherein said metal film is a transition metal selected from the platinum family comprising platinum, palladium, iridium and rhodium.

5. A glow plug as claimed in Claim 1 wherein said heater element (24) is a metal alloy film having a resistance greater than 0.2 ohms.

6. A glow plug as claimed in Claim 5 wherein said metal alloy has at least one constituent selected from the platinum family comprising platinum, palladium, iridium and rhodium.

7. A glow plug as claimed in Claim 1 wherein said cylindrical substrate (22) is a ceramic substrate.

Patentansprüche

1. Glühkerze, bestehend aus einem hohlen, zylindrischen Metallmantel (12), einem axialen konzentrisch im Mantel (12) isoliert angeordneten Anschluß (36), einem elektrisch nichtleitenden, zylindrischen Substrat (22) mit einem innerhalb des Mantels (12) durch den axialen Anschluß (36) gehaltenen inneren Abschnitt (28) und einem sich axial aus dem Mantel (12) erstreckenden äußeren Abschnitt (30), einem Heizelement (24) aus einem Widerstandsflächenfilm, das mindestens auf der äußeren Fläche des Substrats (22) angeordnet ist, wobei ein Ende des Heizelements (24) in elektrischen Kontakt mit dem Mantel (12) und das andere Ende des Heizelements (24) in elektrischen Kontakt mit dem axialen Anschluß (36) steht, dadurch gekennzeichnet, daß das zylindrische Substrat (22) eine konzentrische Bohrung (26) aufweist, die sich durch die gesamte Länge des Substrats (22) erstreckt und daß sich das Heizelement (24) um das Ende (52) des äußeren Abschnitts (30) des Substrats und längs der inneren Fläche der axialen Bohrung (26) erstreckt.

2. Glühkerze nach Anspruch 1, wobei das Heizelement (24) einen Widerstand von größer als 0,2 Ohm aufweist.

3. Glühkerze nach Anspruch 1, wobei das Heizelement (24) ein metallischer Film ist.

4. Glühkerze nach Anspruch 3, wobei der metallische Film ein aus der Platin-Familie bestehend aus Platin, Palladium, Iridium und Rhodium bestehendes Metall ist.

5. Glühkerze nach Anspruch 1, wobei das Heizelement (24) ein Film aus einer Metallegierung mit einem Widerstand von größer als 0,2 Ohm ist.

6. Glühkerze nach Anspruch 5, wobei die metallische Legierung mindestens eine Bestandteil aufweist, der aus der Platin-Familie bestehend aus Platin, Palladium, Iridium und Rhodium ausgewählt ist.

7. Glühkerze nach Anspruch 1, wobei das zylindrische Substrat (22) aus Keramik besteht.

Revendications

1. Une bougie à incandescence comprenant une gaine métallique cylindrique creuse (12), une

borne axiale (36) disposée concentriquement dans ladite gaine (12) et isolée de celle-ci, un substrat cylindrique non-conducteur d'électricité (22) ayant une partie interne (28) gardée dans la gaine (12) par la borne axiale (36) et une partie externe (30) se prolongeant axialement à partir de la gaine (12), une résistance chauffante stratiforme (24) disposée le long d'au moins la face externe du substrat (22), une extrémité de ladite résistance chauffante (24) étant en contact électrique avec la gaine (12) et l'autre extrémité de la résistance chauffante (24) étant en contact électrique avec la borne axiale (36), caractérisée en ce que le substrat cylindrique (22) comprend en outre un alésage concentrique (26) traversant toute la longueur du substrat (22), et ladite résistance chauffante (24) se prolonge autour de l'extrémité (52) de la partie externe (30) du substrat et le long de la face interne de l'alésage axial (26).

2. Une bougie à incandescence selon la revendication 1, dans laquelle ladite résistance chauffante (24) a une résistance supérieure à 0,2 ohms.

3. Une bougie à incandescence selon la revendication 1, dans laquelle ladite résistance chauffante (24) est un film métallique.

4. Une bougie à incandescence selon la revendication 3 dans laquelle ledit film métallique est un métal de transition choisi dans la famille du platine comprenant le platine, le palladium, l'iridium et le rhodium.

5. Une bougie à incandescence selon la revendication 1 dans laquelle ladite résistance chauffante (24) est un film d'alliage de métal ayant une résistance supérieure à 0,2 ohms.

6. Une bougie à incandescence selon la revendication 5, dans laquelle ledit alliage de métal a au moins un constituant sélectionné dans la famille du platine comprenant le platine, le palladium, l'iridium et le rhodium.

7. Une bougie à incandescence selon la revendication 1 dans laquelle ledit substrat cylindrique (22) est un substrat en céramique.

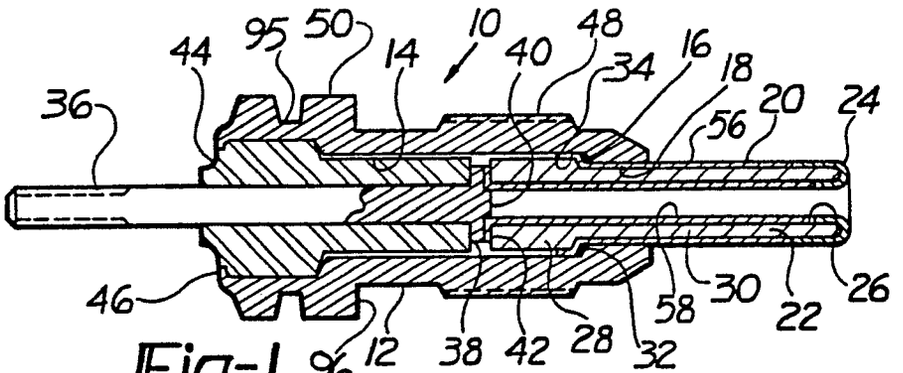


Fig-1

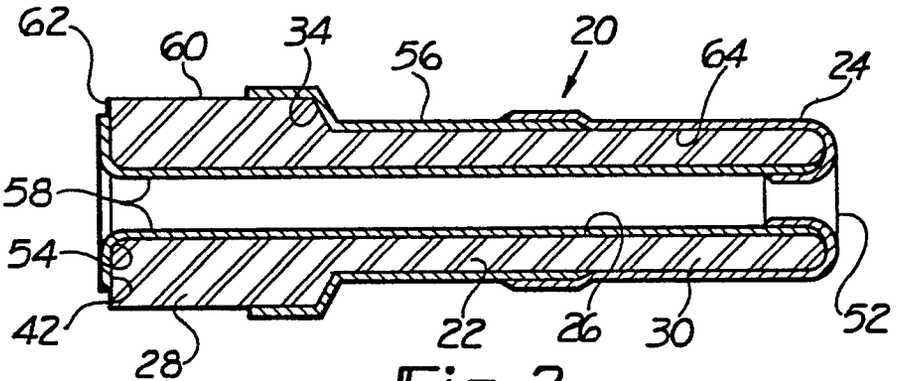


Fig-2

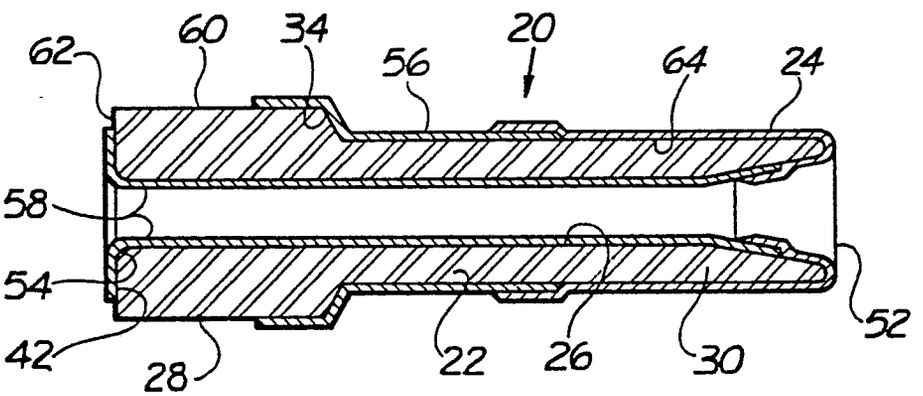
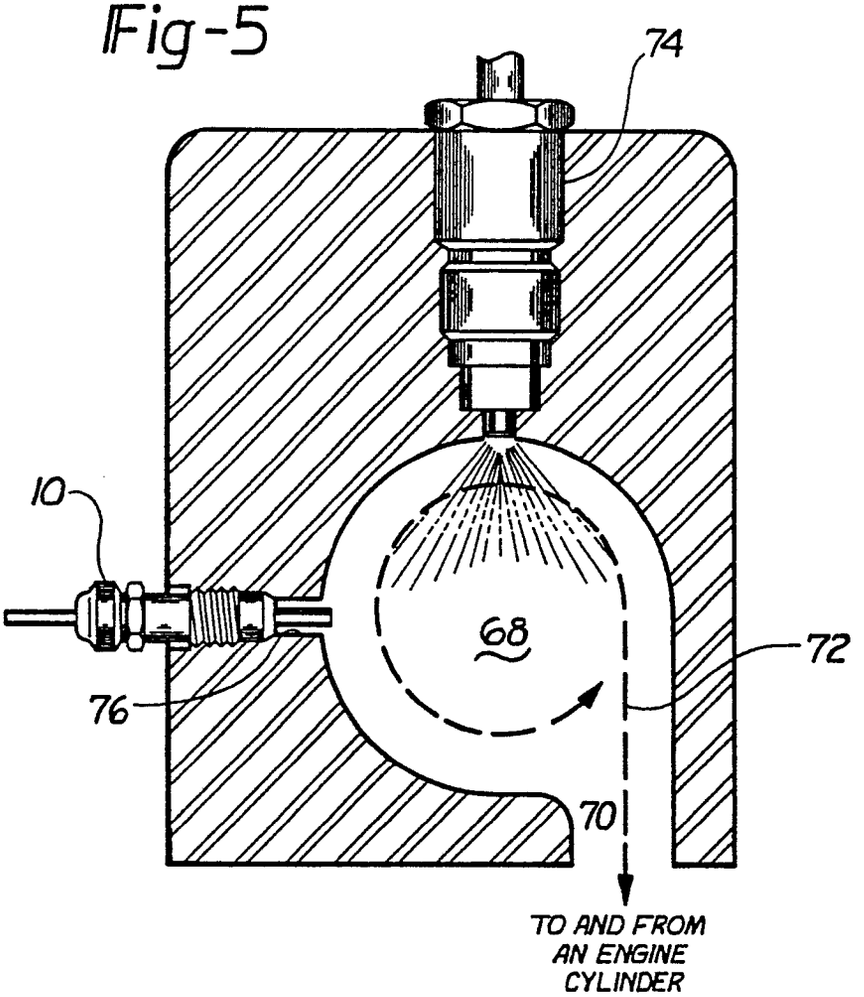


Fig-3

Fig-5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TO AND FROM
AN ENGINE
CYLINDER

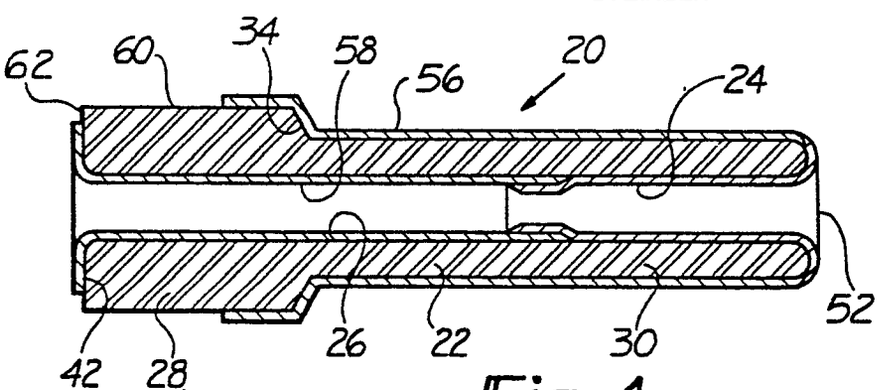
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Fig-4